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ABSTRACT

Environmental Education since its emergence, through the international conferences of the 1970s, has been described as an interdisciplinary field which means that it requires contributions from a number of other disciplines, science being one of them. Many educators have questioned the possibility of traditional school disciplines to promote the Belgrade Charter view of environmental education, because of the content taught, the authoritarian teacher-student relationships, the methodologies followed in teaching, the avoidance of handling controversy in the classroom, etc. In this paper, it is suggested that taking into account the poor delivery of environmental education (after about thirty years of its existence in educational systems), it would be more productive to try to find the aspects that unify science and environmental education. In this paper, firstly, the current status of environmental education in school curricula and the current views about science education are briefly examined. The organization and content of, and the processes followed in, teaching a science course for prospective primary school teachers are described. This course is inspired by the ideas expressed in the STS (Science, Technology, and Society) movement. Some evaluation results are presented supporting the thesis that merging science and environmental education is mutually beneficial. (Contains 24 references.) (Author/YDS)

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Science and Environmental Education: Can They Really be Integrated?

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ABSTRACT

Environmental Education since its emergence, through the international conferences of the 70s, has been described as an interdisciplinary field which means that it requires contributions from a number of other disciplines, science being one of them. Many educators have questioned the possibility of traditional school disciplines to promote the Belgrade Charter view of environmental education, because of the content taught, the authoritarian teacher– student relationships, the methodologies followed in teaching, the avoidance of handling controversy in the classroom, etc. In this paper it is suggested that taking into account the poor delivery of environmental education, after about thirty years of its existence, in educational systems, it would be more productive to try to find the aspects that unify science and environmental education.

In this paper firstly, there are briefly examined the current status of environmental education in school curricula and the current views about science education. The organization, the content, and the processes followed in teaching, of a science course for prospective primary school teachers are described. This course is inspired by the ideas expressed in the STS movement, and its main characteristic is that, contexts for teaching science had been issues from every day life such as the environmental ones. Some evaluation results are presented supporting the thesis that merging science and environmental education is mutually beneficial.

INTRODUCTION

Environmental education since its emergence, through the international conferences of the 70s, has been characterized as an interdisciplinary field which means that it requires contributions from a number of other disciplines. Concerning its delivery in formal education, a common thesis was that it cannot be a separate self–contained subject but rather that it should be integrated to all disciplines taught in school. There was a widespread view that science would be one of the main subjects of the school curriculum that can accommodate environmental education. But in an early stage there were educators who questioned the possibilities of school disciplines, science included, to promote the Belgrade Charter view of environmental education (for instance: Lucas,

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1980; Robottom, 1983; Robottom, 1984; Maher, 1986). They argued that the structure of school disciplines, the authoritarian teacher– student relationships, the text base patterns of instruction, the avoidance of handling controversy in the classroom, can only promote the less controversial components of environmental education as it is knowledge and skill development. Which means that it promotes the education *in* and *about the environment* while neglecting the education *for the* environment, which is more radical, as it is focused mainly on the ethical dimensions of the issues, the promotion of critical thinking, attitudes and behavior. In advance for school science, Robottom (1983) argues that this subject is a limited vehicle and for the reason that it promotes a positivistic world–view not compatible with the aims of environmental education.

This paper, argues that a careful look at many of the proposals concerning the aims, the content and the teaching methods for both environmental and science education as far as the new trends of the later is concerned, many things exist in common. From this comparison one can arrive at the conclusion that science education does have a central role to play in promoting environmental education from which a reciprocal benefit can be derived.

So in this paper firstly, are briefly examined the current status of environmental education in school curricula, the current views about science education, and its relation to environmental education is outlined. Then a science course organized for student–teachers is briefly described and some evaluation results are presented supporting the thesis of this paper that merging science and environmental education is mutually beneficial.

ENVIRONMENTAL EDUCATION IN SCHOOL CURRICULA

In spite of the enthusiasm that accompanied the emergence of environmental education in terms of its promotion, it remains a fact beyond dispute that its incorporation into the educational systems all over the world is still problematic. A lot of progress has been done by producing teaching materials, of high standards in many cases, many successful practices have been reported, a lot of research evidence is available but in practice environmental education has not been part of all pupils' education. No country can claim that has fully incorporated environmental education into the school curricula, in spite of the many official statements. I will refer to the specific case of two countries. One will be U.K. where environmental education is officially considered as a cross curricular area and my country, Greece, where environmental education is implemented through separate projects dealing with environmental issues.

In England, according to Oulton (1994), "Curriculum Guidance 7, using the well rehearsed formula of education *about, in* and *for* the environment, sets out the way in which this may be achieved through the contribution of individual subjects and by the development of a co–ordinated policy across both the formal and non-formal aspects...". But as he points out, the documentation in not statutory such as in English

and science which means that the guidance to schools is about what *should* do rather than what they *must* do. In practice, the disciplines that mainly accommodate environmental education within the timetable curriculum are science and geography (Gayford, 1996). According to Oulton's (1994) views "...although there are some teachers that are carrying effective environmental education strategies in many schools and a few schools are beginning to consider whole school strategies, the vast majority of pupils do not currently receive a comprehensive environmental education experience".

In Greece, environmental education has the official recognition, but the form which is supported by the Ministry of Education is the implementation of separate projects. This has as a consequence environmental education to remain in the periphery of the curriculum. This is one of the reasons that only some motivated teachers are involved, doing in many cases of high quality work, but usually after implementing one or two projects, they give up the effort because they face many difficulties. They have to invest extra time as very often they work outside of the school timetable during the implementation of the project. It is estimated that only 10% of the teachers are involved each year, which means that environmental education is optional for pupils.

Taking into account the poor delivery of environmental education in formal education, for a variety of reasons, the role of school in promoting the environmental literacy of all citizens is at least questionable.

NEW TRENDS IN SCIENCE EDUCATION

If we take a fresh look at the relation between science and environmental education we will have to seriously consider the changing views overtime concerning science education. For the last decades there has been a tendency to renew science education at schools so as to respond to the new transformations that occur in society. School science, had been criticized by many educators and others for being taught as though all pupils should become practicing scientists. In advance, research on pupils' alternative conceptions unfolded problems related to teaching and learning and a view has been established that science knowledge taught in school is not internalized (for instance: Driver et al, 1985; Osborne et. al, 1987).

There have been calls for transforming science education from something focused on abstract factual knowledge promoting fragmented learning to a discipline focused on preparing future citizens able to understand and cope with the science related societal issues. Scientific literacy for all citizens, becomes the new focus of science education. Hurd (1998), one of the supporters of these changes, mentions that science itself is changing in many terms. He points out that science is becoming more holistic in nature and in practice, there is a move from single disciplinary based studies to cross–disciplinary ones. Research is now focused mainly on the functional aspects of science/technology as it relates to human welfare, economic development, social progress, and the quality of life than in the establishment of new theories and laws as happened in the past.

As a response action to these views the movement STS (Science, Technology & Society) came into being. STS education has as its focus the scientific literacy of all students independently of the profession they are going to follow. It aims to equip learners with the knowledge and skills needed to cope with and successfully resolve personal and societal problems (see for instance Bybee, 1984; Hofstein & Yager 1982; Miller, 1984; Yager, 1992; Solomon & Aikenhead, 1994).

In the last decade, the terms "public understanding of science" and "social responsibility of science" are connected to science education at schools. The first one, according to Cross (1999), is used by those who see it as a means of furthering the continued development of the technocratic society and aims to educate people to support and cope with what the experts provide rather than to question their products. The second is characterized as more radical and is used by those who connect the overcoming of the environmental and ecological threats facing the world, with some kind of social change.

Focusing science education on preparing scientifically literate citizens prerequisites many changes concerning the content, the organization and the pedagogy of school science. According to Yager et al (1995), "there is the perceived need for something different from the conceptual schemes (discipline structures) used by practicing scientists. Different organizers are needed in schools. ... and the new organizers should be issue based...". Some characteristics of the STS approach are the deep involvement of students in investigating problems and the promotion of a multidisciplinary view, as problems have not only scientific aspects.

It seems that science education once again in its history is on its way to transformation so as to respond to the demands of the present digital era where science as a discipline play a vital role in many ways in our every day life. But changing the well-established tradition in science education is not an easy task. This is the reason why STS movement although it has gained an extended support, as one can judge from the literature, its translation to school practice still remains problematic. A number of different approaches are being explored, and at the same time, many questions arise concerning the content, the outcomes of the STS curricula, and the way of integrating these into current science education practice. McFadden (1991), based on the experience of a Canadian STS curriculum, discusses some of the problems that arise in practice.

Comparing the proposals concerning the current views about science education just outlined and the views held about environmental education one can notice that these fields have many in common as far as the aims, the content and the teaching methods are concerned. Volk (1984) points out many of the common goals and practices that these fields share. For science education dealing with environmental issues, add relevance to learning, as these are real problems, and so will be seen by students as worthy of consideration. On the basis that maintaining the health of the environment is going to be the most important task that the humanity will face in the future, education must play a vital role for that. Environmental literacy apart from environmental concern, prerequisites some knowledge from many areas, science included. The development of

problem solving and decision making skills is common aim for both science and environmental education. Zoller (1987), one of the supporters of the teaching of science through the environmental issues (STES education) emphasizes the possibilities for enhancing problem solving and decision making skills. Science education in its way to transformation may very well find an ally and resource in environmental education concerning practice. Many teaching approaches such as active involvement of students, issue investigation, analysis, evaluation of alternative solutions to problems etc. have developed, in the field of environmental education and some teachers have been familiarized with them, science teachers included.

INTEGRATING SCIENCE AND ENVIRONMENTAL EDUCATION INTO INITIAL TEACHER EDUCATION

In Greece the majority of the students come to Primary Education Departments from high school with a very poor background in science, as science is not one of the subjects taught as sine qua non for university entrance examinations. Also research evidence has confirmed their poor understanding of many basic science concepts (Papadimitriou, et al., 1993; Papadimitriou, 1994). It thus appears that science taught in schools does not help them understand the scientific part of every day life issues.

On the basis of the belief that merging environmental education and science education, would be mutually beneficial, we attempted to organize a science course for prospective primary school teachers. The main feature of that course is that science concepts are taught not in the context of the discipline but in the context of issues from every day life, such as the environmental ones.

It has been assumed that this way would be more attractive for students and more effective in providing them with the necessary science knowledge for both their own scientific and environmental literacy and their professional development. Inherent is the hope that if teachers get familiar with innovative ways of teaching and learning during their initial teacher training, they will adapt more easily such ways in their practice when they become teachers.

Content and process of the course

The environmental issues selected to constitute the context for teaching, were the following: drinking water, greenhouse effect, ozone layer depletion, acid rain and plastics. These were selected on the basis of their importance in our every day life and because these can impart a great deal of science knowledge. For each one of these issues modules were prepared in which, apart from the scientific part, emphasis is given to other dimensions of these issues as well, through stimulus materials and background information in the form of printed information which provided as part of each module.

46 students, in their first year of studies, participated in the course, which lasted one semester for 3 hours per week. Students worked in groups of four, implemented the proper experiments in each section, observed the results and responded to them. They

were prompted to discuss their findings with other students in the group and with tutors. Emphasis was placed on the use of scientific knowledge in terms of the issue. By using the supporting materials, that accompany each module, and with the help of stimulus questions, students were encouraged to discuss, analyze and reflect on several dimensions of issues such as scientific, social, political and economic and also to seek solutions to the problems.

Evaluation and outcomes

The evaluation of the course was based on pre– and post– instruction questionnaires. Not all the expected outcomes were evaluated during this stage of the course. In fact, at this stage the evaluation focused mainly on the cognitive outcomes in relation to the particular issues, which were focused on finding out students' understanding of each one of these issues, as well as their ability to use scientific terms in expressing their views. So each one of the questions were of an open type aiming at finding:

(a) What they know about each one particular issue

(b) Their views about the compounds that cause it

(c) Where these compounds come from

(d) Their views about consequences of the environmental problem

In both questionnaires students were asked the same questions. The post–instruction questionnaire was given to them one week after finishing the course.

The findings from this evaluation have been presented and discussed in detail elsewhere (Papadimitriou, 1995, 2000a, 2000b). Here, only some extracts of these data will be presented for supporting the claims of this paper concerning the benefits gained of this kind of course for both science and environmental education.

Benefits for science education

In the following table some data, coming from the pre– and post– instruction questionnaires, which concern the learning in science and the application of the knowledge learned in understanding scientific aspects of three environmental problems –acid rain, greenhouse effect and ozone layer depletion– are presented.

Students' responses to the questions concerning the scientific aspects of the three phenomena.

The main categories of students' responses	Pre- instr. n=46	Post-instr. n=46
ACID RAIN		
Rain that contains acids or acidic compounds	7	39
Mention the H_2SO_4 or HNO3 or both	-	44
Rain that contains pollutants	25	3
Rain with pH <5,6	-	31
Responsible compounds for acid rain are sulfur and nitrogen oxides	9	39
GREENHOUSE EFFECT		
Temperature rise because of the absorption of solar radiation	23	45
Mention UV radiation	6	42
Mention only (CO2) as greenhouse gas	16	7
Mention more than one of the greenhouse gases	3	36
OZONE LAYER DEPLETION		
The ozone exists in the upper atmosphere	6	42
Mention the ozone of the lower atmosphere	-	29
Destruction of the ozone caused by the content of the sprays (without mentioning the CFCs)	25	5
Destruction of the ozone caused by CFCs	3	41

The number of answers exceeded the number of students (46) as some of them gave more than one answer.

Some of the conclusions drawn form the evaluation can be summarized as follows:

Remarkable progress in using more scientific terms in students' language can be noticed by looking at their answers in the above table. For instance the number of students who give the scientifically acceptable views has considerably increased after instruction, as 39 of them mention sulfur oxides and nitrogen oxides as the compounds that cause acid rain, while in the pre–instruction questionnaire only in 9 of their answers refer to oxides.

Apart from the data summarized in the table there are some other findings deserving attention. Part of them concern students' views about the consequences of the acid rain. In their pre–instruction answers to this question the majority uses more generalized terms as «harmful rain», «has caustic effects», «catastrophic», «makes holes», «blackens the buildings as, for instance, in Athens», «harmful for people because it contains dangerous acids». While in the post instruction questionnaire their answers are more specific as they mention that acid rain is harmful for vegetation, for organisms in the aquatic environments, for ground, for buildings and monuments.

Another point worth mentioning is the improvement of their performance in writing chemical formulas and chemical equations. So in the pre– instruction questionnaire, only few (5 out of 46) wrote 1–3 chemical formulas overall and no one wrote even one chemical equation. While in their responses to post–instruction questionnaire although they were not asked to do so, the majority wrote many of them. More specifically, 27 wrote the chemical formulas of the oxides, 29 of the sulfuric acid, 13 of the nitric acid. Also a considerable number of them wrote the chemical equations of the reaction of the SO3 with water and the reaction of sulfuric acid with the CaCO3 when they mention the harm that acid rain causes to marbles.

Benefits for environmental education

The discussion concerning the benefits for environmental education will be focused on describing briefly of what came out in dealing with one of the issues, the drinking water, as students showed a special interest for this because it is a local problem of great concern. What they knew from the beginning was that there is a problem with drinking water in the city where they live because of the peculiar taste it has.

With the help of the scientific knowledge they gained, the relevant supporting material, and the stimulus questions they discussed about different aspects of the issue such as: the factors that affect the quality of water, the problems connected to the availability, the policies on the part of the government and local authorities, the local conflicts around the water, the role of the industry, the actions of the farmers, the role of the citizens, the ethics implied. They also stimulated, through the questions, to discuss possible solutions to the problem. In their discussion they made use many times of the science knowledge gained such in the discussion concerning the quality of the bottled water by examining the analysis written on labels, also in discussing the purification process before the water reaches our home. Some who live outside the city in close villages asked for permission to borrow the chemicals used in the lab to test for nitrates in the water they drink. They discussed about the climate change and the ground water availability, also examined the international dimension of the problem in connection with conflicts in Middle East and with development by comparing, through given charts, the consumption of water in different areas of the planet.

In conclusion, during the study about each one of the environmental issues they had the opportunity to meet many of the aims of environmental education, such as awareness, holistic approach, handling controversy, opportunities for developing communication and critical thinking skills, examination of alternative solutions to the problems.

CONCLUSIONS AND IMPLICATIONS

In the begging this paper briefly discussed the problems and the constraints in delivering environmental education in schools. If environmental education is to be seriously considered, by the educational community, as a dimension of the traditional disciplines, (science included) the emphasis must not only laid on its contribution in raising aware-

ness about the environment and in the formation of developing attitudes, but also on its potential to contribute to the achievement of the particular goals of each one of these disciplines and of the education as a whole.

The evaluation of the course just described showed that the approach and strategy adopted, constitute in themselves a way of integrating science and environmental education, rendering them mutually beneficial. It appears that students gain a better understanding of science concepts, a better understanding of the issues studied, and the ability to use science knowledge that have learned, in dealing with different aspects of these issues. Also the content and the process followed construct a framework meeting many of the goals of environmental education.

The course described it is not seen as an end in itself; it needs improvements in both, the content and the process followed. For instance we think of involving some fieldwork. It is important to train prospective teachers through such innovative courses so as to become familiar with approaches that meet both the aims of science and environmental education as well. Such familiarization entails the possibility of adapting such approaches in their school practice.

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